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REPORT AND PRELIMINARY RESULTS OF
R/V POSEIDON CRUISE 296
LAS PALMAS (SPAIN) - LAS PALMAS (SPAIN)
April 04th -April 14th, 2003

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1. Participants

Participants Poseidon Cruise 296

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2. Research Objectives

The upwelling area off NW-Africa is one of the most important upwelling systems of the global ocean influenced by high amounts of Sahara dust which is transporting nutrients into the ocean. Both factors are of fundamental importance for the particle production in the ocean influencing the processes of the biological carbon pump system. Hence, they are controlling factors of the global atmospheric CO_2-budget. Despite the main driving-force for climatic variability is located in the North-Atlantic, the upwelling area off NW-Africa is suitable to reconstruct the past climatic variability, via observation of present in-situ environmental datasets.
The research topics were carried out in correlation with the following projects:

2.1 ESTOC (European Station for Time series in the Ocean, Canary Islands)

One goal of POS 296 cruise will be the work at ESTOC station, which is located 60 nm north of Gran Canaria (29°10`N, 15°30`W) in the eastern boundary flow of the subtropical North Atlantic gyre. Standard parameters of hydrography, nutrients, oxygen, chlorophyll a and DIC have been determined monthly since 1994. In addition, long term particle flux has been determined with moored traps since 1991 and seasonal with free-drifting traps. This time-series station is now co-operated by the ICCM (Instituto Canario de Ciencias Marinas) and the GeoB (Department of Geosciences, University Bremen). The main purpose of the station is to build up a long-term oceanographic data base in order to be able to discern seasonal from long-term variability of hydrographic and biochemical parameters in this environmentally sensitiv region.

2.2 DOLAN (Operational Data Transmission in the Ocean and Lateral Acoustic Network in the Deep-Sea)

During POS 296 cruise, it is planned to work on the DOLAN site as well. The DOLAN station is located 25 nm west of ESTOC and comprises technical devices for transmission of scientific data sets by means of acoustic communication in the water column via satellite into the internet and research institutes.

2.3 ANIMATE (Atlantic Network of Interdisciplinary Moorings and Time series for Europe)

Finally, the third task will concentrate on the ANIMATE EU project, which is closely linked to ESTOC and DOLAN. In the ANIMATE project, moorings were deployed on key sites in the northern Atlantic (ESTOC, Canary Islands; PAP, Porcupine Abyssal Plain; CIS, Central Irminger Sea) in order to gain data of CO_2, nutrients and fluorescence, which will be transmitted directly via satellite to the participating scientific institutes. A significant element in ANIMATE is the transmission technology used in the DOLAN project. Till year 2003, ESTOC was used as reference site for the subtropical NE-Atlantic within the ANIMATE project. During this cruise a separate AMINATE mooring (ACI_2), consisting of several scientific sensors (MicroCat, ADCP, Currentmeters) should be moored 25 nm northwest of ESTOC site.

3. Narrative of the Cruise

R/V Poseidon left the port of Las Palmas on April 4th with heading to DOLAN position. Underway 6 XBT´s were launched. During the morning of April 5th the DOLAN surface buoy (SBU) was recovered successfully. The station work was continued with two CTD/Rosette casts down to 3602 m water depth and finished by deploying a NOAA drifting buoy at 20:00 am. In the morning of April 6th R/V POSEIDON reached the position of the former CI15/ACI_1 mooring. It was assuming that the mooring was broken, some month after deployment. Several tries to release the ANIMATE ACI_1 mooring failed and we decided to leave the position and make another try to recover ACI_1/CI 15 later, during the cruise. The station work was continued with communication tests of inductive modems during the afternoon. In the beginning of April 7th the scientific task started with a CTD/Rosette cast down to 3630 m. After that, the DOLAN Multi Sensor Device (MSD) mooring was released and completely recovered in the afternoon, at 2:00 am. Finally, the station work was finished with another CTD/Rosette cast. During April 8th, the DOLAN mooring was redeployed in two steps. In the first part, a dummy was deployed and the anchor was slipped afterwards. In the afternoon the dummy package was recovered again and replaced with the DOLAN surface data buoy. At 20:00 am all test were secluded.

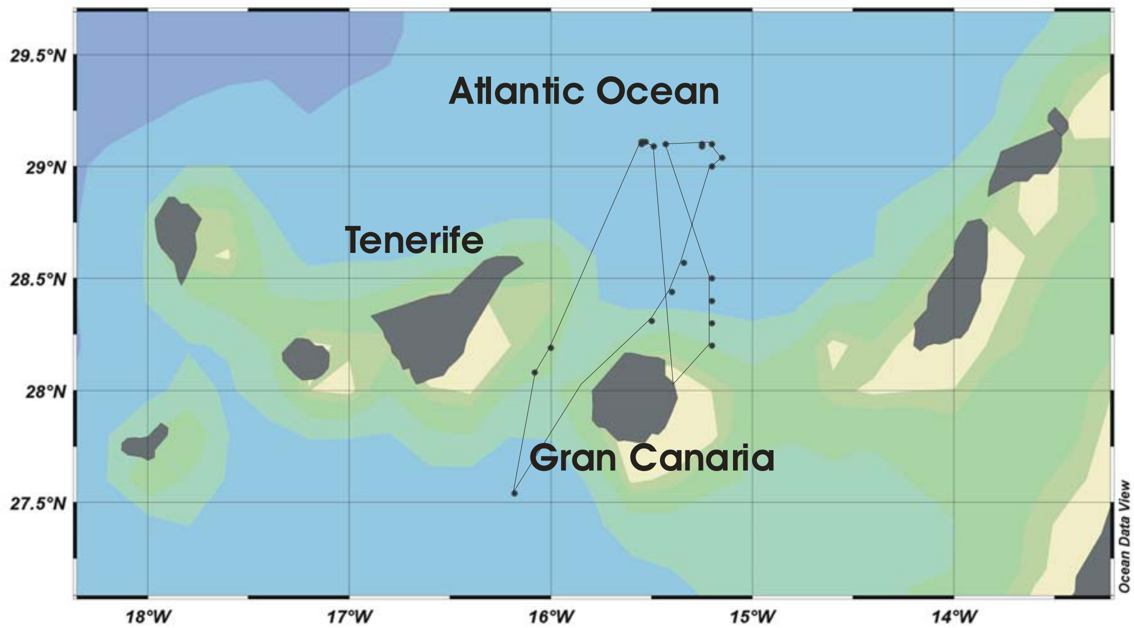


Figure 1: Cruise track R/V POSEIDON cruise 296

During the next two days, three CTD/Rosette station were run on a transect between Tenerife and Gran Canaria. Scientific work on April 11th started with another CTD/Rosette cast down to 3603 m. Subsequently we tried again to release the broken CI_15/ACI_1 array without success. R/V POSEIDON left this site with heading to ESTOC station, where we deployed the CI_16 mooring, in the late afternoon. During night, R/V POSEIDON moved on to the new ACI-mooring located 5 nm SE of the DOLAN data buoy. On April 12th, the new ACI_2 mooring was deployed again. Finally, the station work was finished with a CTD/Rosette cast down to 3622 m water depth. Due to the upcoming bad weather conditions the research work was cancelled on April 13th and R/V POSEIDON steamed back to Las Palmas harbour.

4. Scientific Report

4.1 Equipment Development and Tests

4.1.1 DOLAN Surface Buoy (SBU) and Multi Sensor Device (MSD)

The DOLAN SBU mooring has been broken in December 2002. The drifting buoy was recovered by a Spanish SAR ship and shipped to the ICCM (Instituto Canario de Ciencias Marinas) on Gran Canaria. Scientists from University Bremen removed the electronics and the control mast of the buoy and sent it back to Bremen for repair. A new mast of stainless steel was prepared in Bremen and some more sensors and satellite communication units were added. The new mast has been mounted on the buoy inside the harbour of Las Palmas, before the R/V POSEIDON cruise 296.

Figure 2: Upgrading of the DOLAN buoy inside Las Palmas harbour.

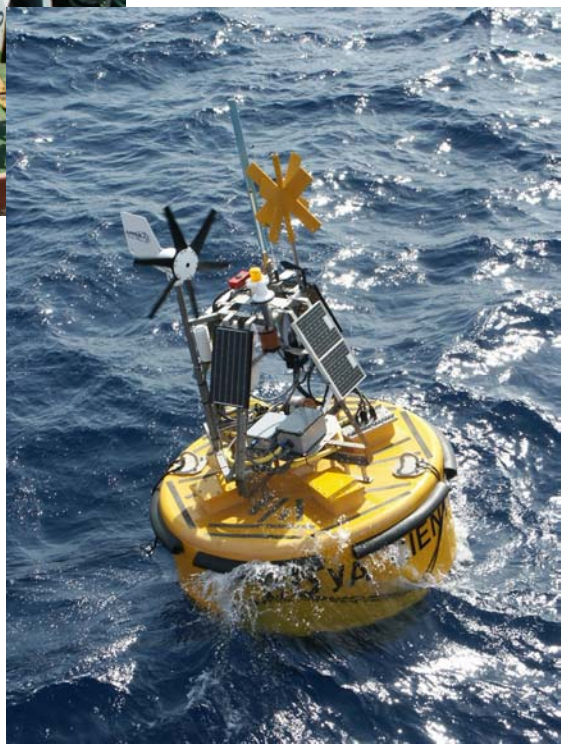
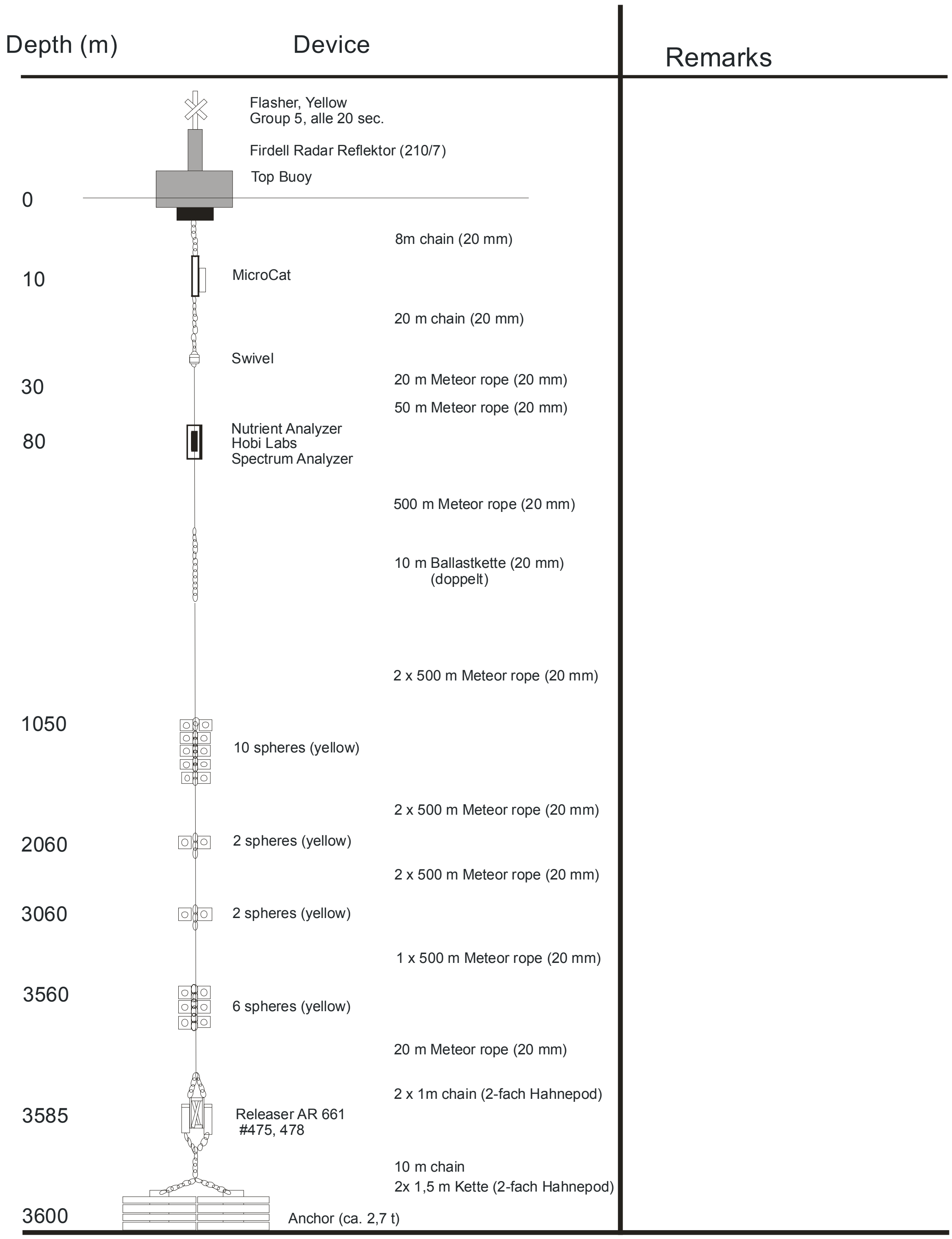


Figure 3: DOLAN buoy with the new mast and new configuration after deployment.

During the forenoon on the April 5th the remaining buoy mooring was released. All sensors, which were attached into the chain below the SBU-data buoy, could be recovered successfully. This comprises the fluorometer and the acoustic transducer. The nutrient sensor which was fitted into a steel cable below the swivel got lost. The new DOLAN SBU mooring was redeployed on April 8th.



Mooring: DOLAN SBU (Top buoy)

Expedition: POS 296 **Position** 29°11,33'N; 015°54,9'W

Area: Canary Islands, 25nm west of ESTOC Station

Water depth: ca 3600m

Date: 08.04.2003

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	Rel	5844
	#478: I/R	5850
	Rel	5859

Figure 4: Drawing of the DOLAN-SBU.

Status of DOLAN before POS 296

On the R/V METEOR M53 cruise (2002) the SBU (Surface Buoy Unit) and 0.5 nm apart the MSD (Multi Sensor Device) were deployed.

The MSD contains one Kiel type sediment trap, one FSI CTD/ACM with acoustic current meter and a compass. The PARCA (Particle Camera, based on a Sony VX 1000 camcorder) and a strobe have been mounted in the MSD frame as well. The different sensors were connected to the BC2 computer. The BC2 is able to communicate with the SBU via a bi-directional acoustic modem (MATS, Orca). The SBU contains the counterpart modem, connected to the BC10, the control computer for the DOLAN data buoy. Sensors on the buoy are one wind vane, a cup anemometer and a compass. For tracking purposes one GPS is connected to the BC10. Additionally, a complete separated Tracking Unit, powered by an own Battery pack, is mounted on the buoy. This Unit contains one Panasonic Orbcomm Transceiver with integrated GPS unit. This unit sends the current buoy position once a day.

The other Sensors can be contacted via Orbcomm, the BC10 and the sub-sea link. The sensor data will be sent via Orca modem, BC10 and Orbcomm. For the first tests of the buoy one SATEL packed radio is modem is installed, which can communicate to a ship within a distance of one nautical mile. One ARGOS PTT is mounted on the buoy for tracking because the original tracking unit stopped sending position reports in November 2002. Thus, it was unable to recover the buoy in December 2002.

New Systems on the Buoy

Inmarsat Mini-C

One Inmarsat Mini-C Transceiver (Thrane&Thrane), with integrated GPS, has been mounted on the buoy which replaces the Orbcomm tracking unit.

Wind Generator

A wind generator has been added to support the 24 V power supply network. In addition, a new charging regulator for the generator has been installed, also. This was necessary due to some problems with the power supply of the buoy and the high power consumption of the Orca acoustic modems.

Animate Telemetrie

Some sensors coming from the ANIMATE Project need to be deployed in very precise depth of about 10 m and 80 m below the surface. Because of this it has been decided to put the following sensors into the separate DOLAN SBU mooring instead of the ACI_2 mooring:

Vaisala Weather Sensors:

Air Temperature	
Barometric Air Pressure	
Relative Humidity	
SAMI CO_2	10 m
Microcat	10 m

HS2 Fluorometer	80 m
NAS-2E Nutrient Analyzer	80 m

These sensors shall be integrated into the telemetry as far as possible. The ANIMATE Telemetry has been designed to transmit the sensor data via an Orbcomm transceiver. The SAMI CO_2 sensor and the MicroCat CTD have been integrated into the telemetry and connected to the ANIMATE Telemetry box via a cable. The HS2 Fluorometer and the NAS-2E Nutrient Analyzer have not yet been integrated into the telemetry.

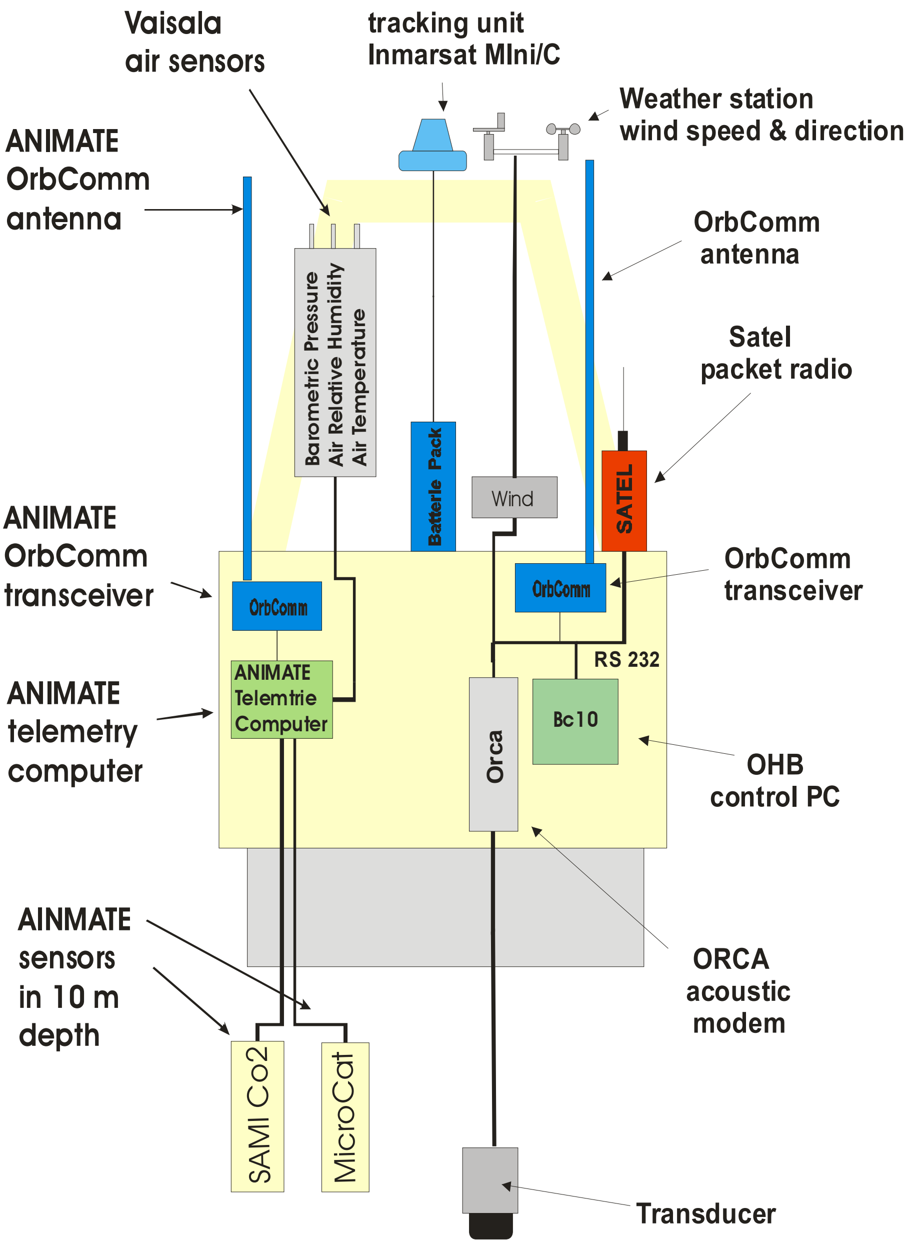

Figure 5: Configuration of the DOLAN Buoy

A Change in the Electrical Architecture

The electrical concept has been changed due to many power problems in the past. The power supply has been split into one 12V power supply for the BC10, the sensors on the buoy, GPS, Panasonic transceiver, Flashlight etc. The high power branch with the Orca modem has its own 24V power supply. The 12V system is supported by two 20W solar panels, the 24V branch by two 10W solar panels and the wind generator (Ampair Pacific 100W 24V).

Test Concept

All systems in the DOLAN Network have been tested on device level before shipment. The whole system has been checked after the assembly, before deployment on deck of the ship. The last test before deployment was the in-situ test with the MSD, lowered by the ships winch down to a depth of 3000 m. The buoy was on board of R/V POSEIDON, but the acoustic transducer was in 5 m depth. For controlling and monitoring reasons, the DOLAN Acoustic Rack has been used to record and monitor the acoustic transmission between SBU and MSD with a second Hydrophone.

All MSD sensors have been addressed on the following path:

Ship (Laptop->SATEL) ->
SBU (SATEL –> BC10 -> Orca Modem) ->
MSD (Orca Modem -> BC2 -> Sensor)

The tests were successful after some adjustments of the modem addresses of some units. After these tests some tests have been performed via the Orbcomm link instead of the SATEL Radio link. These tests are very difficult with the buoy located on board the ship, because the Orbcomm antenna is shielded by the ships facilities, like the A-Frame. The Orbcomm performance of the SBU at sea deployed is much better.

4.1.2 ESTOC / ANIMATE

This study site is located 60 nm north off Gran Canaria in about 3600 m water depth. The mooring was at least deployed during the R/V METEOR cruise M53, 2002.

Before the R/V POSEIDON cruise 296 the ESTOC mooring was coupled with the ANIMATE mooring near the original ESTOC site. On the April 6th it was tried to recover the CI_15/ANIMATE_1 array. Both releasers were contacted without any problems but the mooring does not rise up. During the next 5 hours the releasers were rounded upon several directions. Every time they offer a distance from 3700 m, so we decided to cancel this working part at 3:00 am for that day. On the April 11th R/V POSEIDON reaches again the ESTOC position. We tried again to recover the array. In consideration of the fact, that we get depth between 3630 and 3639 m from both releasers, we assume that the remaining mooring array must be torn off, while the releasers lay at the bottom without buoyancy.

During this cruise, we decided to split the moorings and to place separate mooring arrays for both projects ESTOC and ANIMATE. This has been carried out because of the fact that the moorings, involved in the ANIMATE project, often got lost in the past, what seems to be a problem of the steel ropes in use and the visible surface buoyancy parts of the telemetry.

ESTOC (CI_16, Canary Island Mooring)

The deployment of the ESTOC array was carried out on the April 11th in the afternoon. Attached to the mooring are two sediment traps at depths of 1025 m and 3055 m. The water depth is about 3630 m. The recovery of this array is planned in April 2004 during the R/V POSEIDON cruise 310.

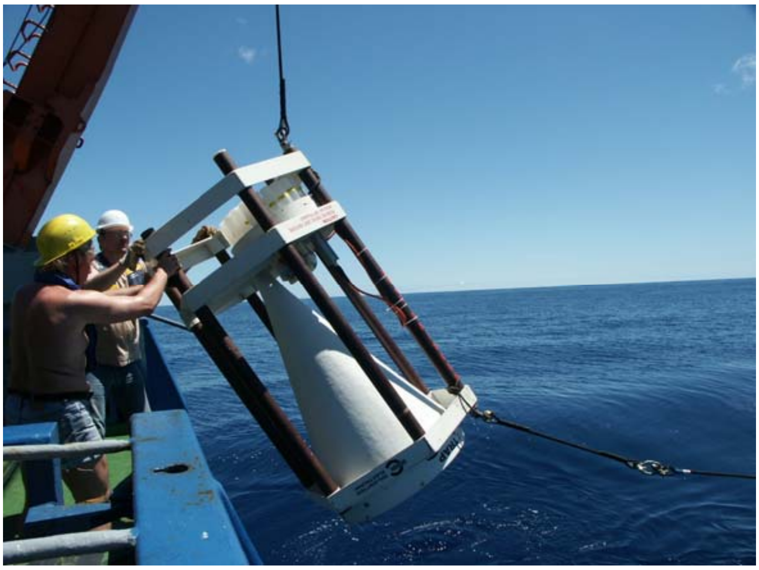

Figure 6: Deployment of the upper sediment trap attached to the ESTOC mooring CI_16.

ANIMATE (ACI_2, ANIMATE Canary Island)

The ANIMATE (ACI_2) mooring was deployed at April 12th, at a water depth about 3600 m. The research site included the ARGOS telemetry buoy, 8 MicroCats, a floatation sphere with integrated ADCP, one sediment trap (McLane, SOC (Southampton Oceanography Center)) and two currentmeter.

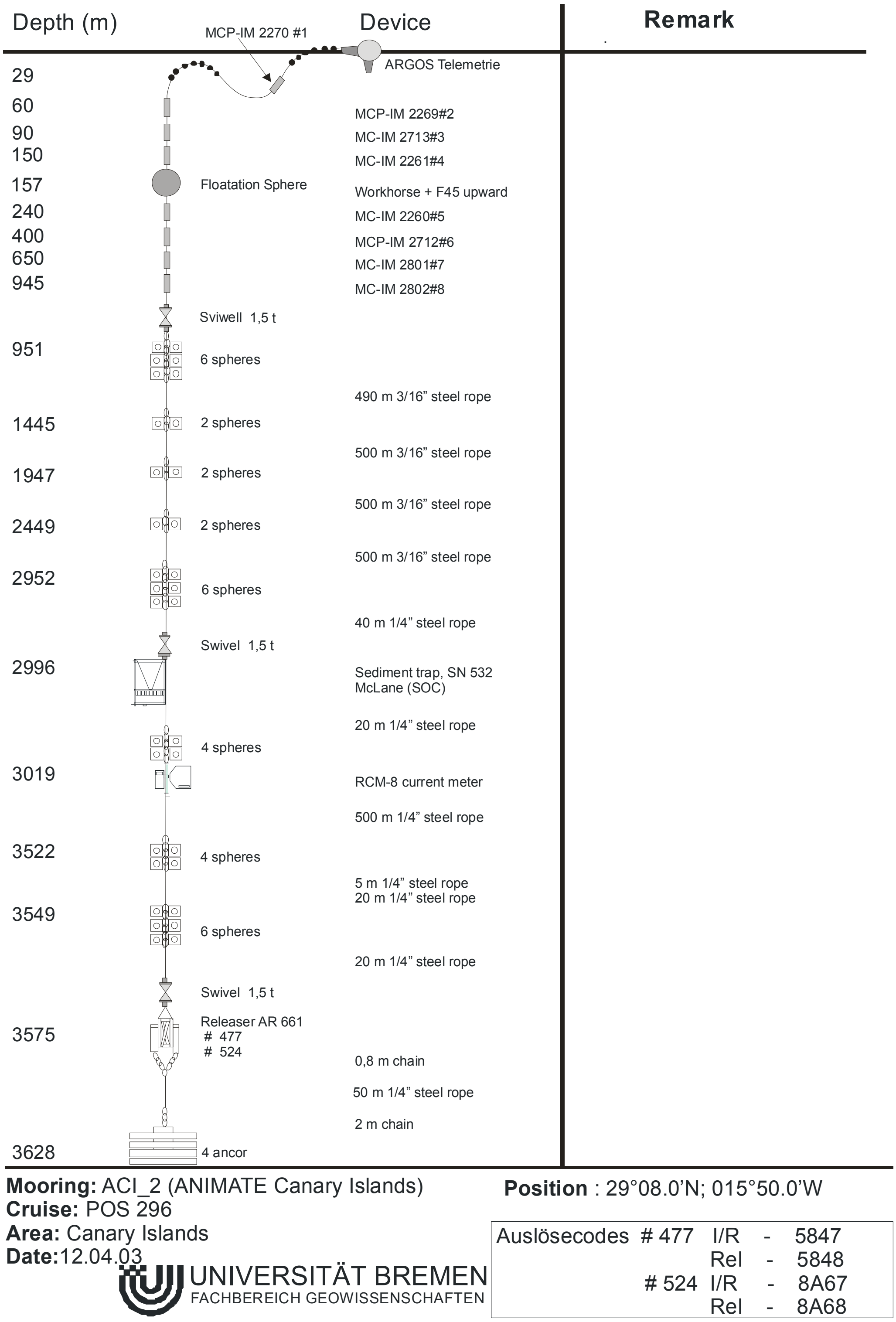

Figure 7: Design of the ANIMATE mooring ACI_2

Figure 8: ANIMATE sediment trap from SOC (McLane SN 532).

4.2 Particle Collection with Sediment Traps

The particulate material collected will be analysed to determine total flux, particulate flux, particulate organic carbon, particulate nitrogen, biogenic opal, carbonate and stable isotopes of organic matter, and lithogenic material. The trapped material also will be investigated for species composition of the planktonic organisms (pteropods, foraminifera, coccolithophorides and diatoms). The objective of these studies is to identify signals of seasonal variations in those components, which play an important role in the sediment formation process. The result of these investigations will form a basis for the reconstruction of paleo-current systems and paleoproduction from the sediments.

4.2.1 ANIMATE / ESTOC

For the R/V POSEIDON cruise 296 it was planned to recover and deploy the ESTOC / ANIMATE array. Attached to this mooring was a sediment trap. Thus, the mooring (CI_15 / ACI_1) got lost and no samples from a sediment trap could be taken on this cruise (Tab.1).

4.2.2 DOLAN-MSD

On the April 7th the recovery of the MSD started. The array was positioned at 29°10,40`N and 15°55,30`W at a water depth of 3630 m. This site was at least deployed during R/V METEOR cruise M 53/1a. It contains among other devices one sediment trap. That MSD trap consists of two sample devices, which both deliver the whole sample set of 20 cups.
The array could not redeploy since the releaser must be used for the new ESTOC mooring (CI_16). But it is planned to deploy a new DOLAN-MSD during the R/V METEOR cruise M58/3 in June 2003.

Table 1: Mooring data for recoveries and redeployments during R/V POSEIDON cruise 296.

Mooring	Position	Water depth (m)	Interval	Instr.	Depth (m)	Intervals (no x days)
Mooring recoveries						
DOLAN						
MSD 1	29°10,40`N 15°55,30`W	3630	16.04.2002 11.04.2003	MSD	3050	1x10, 39x9
Mooring deployments						
ANIMATE						
ACI_2	29°09,60`N 15°50,05`W	3628	20.04.2003 04.04.2004	(SOC) RCM 8	2996 3019	2x21, 11x28
ESTOC						
CI_16	29°04,25`N 15°15,08`W	3600	12.04.2003 06.04.2003	SMT 234 SMT 230	1025 3055	20x18 20x18

Instruments used:

SMT 243	= Titan particle sediment trap SMT 243 KUM, Kiel
SMT 230	= Particle sediment trap SMT 243 KUM, Kiel
MSD	= Particle sediment trap KUM, Kiel
SN 532	= SOC sediment trap
RCM 8	= Aanderaa current meter, RCM 8

4.3 Marine Chemistry

Along this cruise, and as part of the ANIMATE/ESTOC mooring redeployments 4 stations were sampled along 29°N (be aware that St. 47 is the deep cast of St. 45), both at the ESTOC and DOLAN positions and to the west and east; six more stations were also sampled between Gran Canaria and Fuerteventura (see map in Fig. 9). A total of 11 sampling Rosette-CTD stations were made and one more station with CTD and MicroCats; ESTOC was sampled to the bottom, the calibration cast for the fluorometer was only made to 500 m of nominal depth due to restrictions of the device and the rest to 2000 m. A CTD/Rosette unit with 12 bottles from surface to the bottom was used. Physical (CTD, salinity samples at certain depths) and biochemical (oxygen, alkalinity, pH, nutrients, gelbstoff, chlorophyll) parameters were measured in order to characterize the water masses present in the study area (Tab. 2). Some of the parameters (oxygen, alkalinity, pH, gelbstoff, chlorophyll filtration) were analysed on board after sampling and others were taken frozen to the ICCM (nutrients and filters from chlorophyll). Additionally, and as part of the ESTOC customary sampling scheme, 6 XBT's (eXpendable BatiThermograph, T7) were launched to 800 m in the transit from Las Palmas to the ESTOC station (Tab. 3).

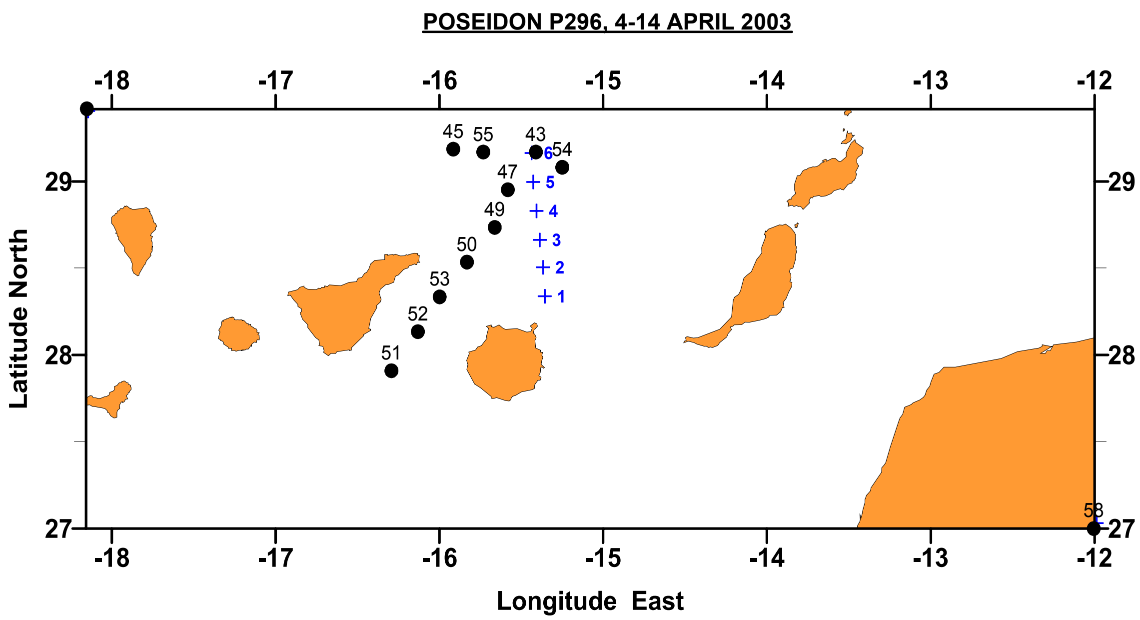

Figure 9: Position of the CTD stations (dots) and XBT launches (crosses) made by ICCM along R/V Poseidon cruise 296.

Table 2: Details of Sampling Stations.
(0=oxygen, A= alkalinity, P=pH, N=nutrients, G=Gelbtoff, S=salinity, C=chlorophyll “a”, E=extra sampling).

Date	St. #, Cast #	water depth (m)	Lat N	Lon W	depth sample	PARAMETERS							
						O	A	P	N	G	S	C	E
05.04	43, 002	3602	29°10.0’	15°24.7’	800	√	√	√	√	√		√	
	ESTOC 04/03				600	√	√	√	√	√		√	
					400	√	√	√	√	√		√	
					300	√	√	√	√	√		√	
					200	√	√	√	√	√	√	√	
					150	√	√	√	√	√	√	√	
					125	√	√	√	√	√	√	√	
					100	√	√	√	√	√	√	√	
					75	√	√	√	√	√	√	√	
					50	√	√	√	√	√	√	√	
					25	√	√	√	√	√	√	√	
					10	√	√	√	√	√	√	√	
05.04	43, 004	3602	29°10.0’	15°24.7’	3503	√	√	√	√	√		√	
	ESTOC 04/03				2999	√	√	√	√	√		√	
					2789	√	√	√	√	√		√	
					2500	√	√	√	√	√		√	
					2000	√	√	√	√	√		√	
					1800	√	√	√	√	√		√	
					1499	√	√	√	√	√		√	
					1300	√	√	√	√	√		√	
					1201	√	√	√	√	√		√	
					1100	√	√	√	√	√		√	
					1000	Niskin bottle did not close							
					800	√	√	√	√	√	√		√
07.04	45, 006	3630	29°11.0’	15°55.0’	508	√	√	√	√	√			√
					150	√	√	√	√	√		√	√
					125	√	√	√	√	√		√	√
ANIMATE Fluorometer calibration at ESTOC					100	√	√	√	√	√		√	√
					90	√			√	√		√	√
					79	√			√	√		√	√
					71	√	√	√	√	√	√	√	√
					54	Niskin bottle did not close							
					41	√	√	√	√	√	√		
					24	√	√	√	√	√			
					10	√	√	√	√	√			
07.04	47, 008	3630	29°11.0’	15°55.0’	3500	√	√	√	√	√			
					2998	√	√	√	√	√			
					2501	√	√	√	√	√			
					2000	√	√	√	√	√			
					1500	√	√	√	√	√			
					1301	√	√	√	√				
					1201	√	√	√	√				
					1101	√	√	√	√				
					956	√	√	√	√				
					801	√	√	√	√				
					600	√	√	√	√				
					300	√	√	√	√	√	√		
09.04	49, 010	3610	28°57.0’	15°35.0’	2001	√	√	√	√	√	√		
					1499	√	√	√	√	√			
					1299	√	√	√	√	√			
					1149	√	√	√	√	√			
					999	√	√	√	√	√			
					799	√	√	√	√	√			
					600	√	√	√	√	√			
					300	√	√	√	√	√			
					122	√	√	√	√	√		√	
					100	√	√	√	√	√		√	
					51	√	√	√	√	√		√	
					9	√	√	√	√	√	√	√	

Table 2: continued

Date	St. #, Cast #	water depth (m)	Lat N	Lon W	depth sample	PARAMETERS							
						O	A	P	N	G	S	C	E
09.04	50, 012	3587	28°44.0’	15°40.0’	2005	√	√	√	√	√	√		
					1500	√	√	√	√	√			
					1300	√	√	√	√	√			
					1149	√	√	√	√	√			
					1000	√	√	√	√	√			
					800	√	√	√	√	√			
					600	√	√	√	√	√			
					300	√	√	√	√	√			
					125	Bottle did not close properly							
					100	√	√	√	√	√		√	
					50	√	√	√	√	√		√	
					10	√	√	√	√	√	√	√	
09.04	51, 014	3436	28°32.0’	15°50.0’	2000	Niskin bottle did not close							
					1500	√	√	√	√	√	√		
					1300	√	√	√	√	√			
					1150	√	√	√	√	√			
					1000	√	√	√	√	√			
					800	√	√	√	√	√			
					599	√	√	√	√	√			
					300	√	√	√	√	√			
					125	Niskin bottle did not close							
					100	√	√	√	√	√		√	
					50	√	√	√	√	√		√	
					10	√	√	√	√	√	√	√	
10.04	52, 015	2521	27°55.0’	16°18.0’	2003	√	√	√	√	√	√		
					1500	√	√	√	√	√			
					1299	√	√	√	√	√			
					1149	√	√	√	√	√			
					999	√	√	√	√	√			
					800	√	√	√	√	√			
					599	√	√	√	√	√			
					298	√	√	√	√	√			
					123	√	√	√	√	√		√	
					99	√	√	√	√	√		√	
					49	√	√	√	√	√		√	
					10	√	√	√	√	√		√	
10.04	53, 017	2291	28°08.0’	16°09.0’	2001	√	√	√	√	√		√	
					1500	√	√	√	√	√	√		
					1300	√	√	√	√	√			
					1150	√	√	√	√	√			
					1000	√	√	√	√	√			
					800	√	√	√	√	√			
					600	√	√	√	√	√			
					300	√	√	√	√	√			
					124	√	√	√	√	√		√	
					100	√	√	√	√	√		√	
					50	√	√	√	√	√		√	
					9	√	√	√	√	√	√	√	
10.04	54, 019	2815	28°20.0’	16°00.0’	2002	√	√	√	√	√	√		
					1499	√	√	√	√	√			
					1296	√	√	√	√	√			
					1150	√	√	√	√	√			
					1000	√	√	√	√	√			
					800	√	√	√	√	√			
					600	√	√	√	√	√			
					296	√	√	√	√	√			
					124	√	√	√	√	√		√	
					100	√	√	√	√	√		√	
					49	√	√	√	√	√		√	
					10	√	√	√	√	√	√	√	

Table 2: continued

Date	St. #, Cast #	water depth (m)	Lat N	Lon W	depth sample	PARAMETERS							
						O	A	P	N	G	S	C	E
10.04	55, 021	3590	29°04.75'	15°15.0'	2999	Microcat cast for calibration prior to							
					3001	deployment. Niskin bottles on the							
					3004	frame to take substandard water for							
					3006	McLain sediment trap.							
					1500	√	√	√	√	√	√		
					1300	√	√	√	√	√			
					1200	√	√	√	√	√			
					1100	√	√	√	√	√			
					1000	√	√	√	√	√			
					800	√	√	√	√	√			
					600	√	√	√	√	√			
					300	√	√	√	√	√			
					125	√	√	√	√	√		√	
					100	√	√	√	√	√		√	
					50	√	√	√	√	√		√	
					10	√	√	√	√	√	√	√	

Table 3: List of XBT that were launched between Las Palmas and ESTOC station.

XBT sta #	Date	Latitude	Longitude
ESTOC-D6	04.04.2003	28°20,02'N	15°29,95'W
ESTOC-D5	04.04.2003	28°30,09'N	15°30,03'W
ESTOC-D4	04.04.2003	28°39,99'N	15°29,98'W
ESTOC-D3	04.04.2003	28°49,85'N	15°30,02'W
ESTOC-D2	04.04.2003	28°59,93'N	15°30,03'W
ESTOC-D1	04.04.2003	29°09,87'N	15°29,95'W

4.3.1 Water Sampling and Analysis

Samples from each depth were collected immediately after the Niskin bottles were on board. The sampling sequence was as follows:

Oxygen

Oxygen was taken in glass bottles of about 125 ml of volume which were previously cleaned and washed with HCl acid and was fixed at once; then it was kept for at least six hours according to WOCE regulations and finally it was analysed at the laboratory on board R/V POSEIDON. The samples were analysed using the method described in the WOCE Operations Manual, WHP Office Report No. 68/91; the final titration point was detected using a Metrohm 665 Dosimat Oxygen Auto-Titrator Analyser.

Nutrients

Nutrients were taken in polypropylene bottles which were previously cleaned and washed with HCl acid and were completely dry. Samples were immediately frozen at -20°C, analysing them as soon as possible after arrival at the laboratory. Freezing the samples is a common practice; it does not or only in a non-significant way affects the nitrate+nitrite and the phosphate values (by a slight decrease) and is not noticeable in the silicate values (Kremling and Wenck, 1986; McDonald and McLunghlin, 1982).

The nutrients determination was performed with a segmented continuous-flow autoanalyser, a Skalar® San Plus System (ICCM).

Nitrate and Nitrite

The automated procedure for the determination of nitrate and nitrite is based on the cadmium reduction method; the sample is passed through a column containing granulated copper-cadmium to reduce the nitrate to nitrite (Wood et al.,1967), using ammonium chloride as pH controller and complexer of the cadmium cations formed (Strickland and Parsons, 1972). The optimal column preparation conditions are described by several authors (Nydahl, 1976; Garside, 1993).

Phosphate

Orthophosphate concentration is understood as the concentration of reactive phosphate (Riley and Skirpow, 1975) and according to Koroleff (1983a) is a synonym of "dissolved inorganic phosphate". The automated procedure for the determination of phosphate is based on the following reaction: ammonium molybdate and potassium antimony tartrate react in an acidic medium with diluted solution of phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-coloured complex, ascorbic acid. The complex is measured at 880 nm. The basic methodology for this anion determination is given by Murphy and Riley (1962); the used methodology is the one adapted by Strickland and Parsons (1972).

Silicate

The determination of the soluble silicon compounds in natural waters is based on the formation of the yellow coloured silicomolybdic acid; the sample is acidified and mixed with an ammonium molybdate solution forming molybdosilicic acid. This acid is reduced with ascorbic acid to a blue dye, which is measured at 810 nm. Oxalic acid is added to avoid phosphate interference. The used method is described in Koroleff (1983b).

Phytoplankton pigments

Pigments were measured using fluorimetric analysis, following the methodology described by Welschmeyer (1994). The determination was achieved using a fluorometer TURNER 10-AU-000.

Salinity

Salinity samples were taken in dark glass bottles which were previously cleaned and washed with HCl acid. Then, they were kept in boxes to protect them from light till analysis on land.
Samples were measured with a salinometer, model Autosal 8400a, whose measurement range was between 0.005-42 (psu), with an accuracy of ±0.003, according to the manufacturer. It was calibrated following the manufacturer´s information and standarizing it with IAPSO Standard Seawater. Salinity values were calculated as practical salinity according to Unesco (1978, 1984).

Chlorophyll

Chlorophyll samples of one liter of water were taken. The chlorophyll samples were filtered inmediatelly and the filters were frozen subsequently at -20°C. Their analyses takes place at the ICCM laboratory on land.

Carbonate system measurements

Carbonate system measurements, in this case pH and alkalinity samples were taken in glass bottles and were fixed immediately on board. Finally, they were also analysed on board along the cruise. Additionaly, fugacity of carbon dioxide in the air and in the seawater was determined using a flow system continuously along the ship track. The pH_t in total scale (mol $(kg\text{-}SW)^{-1}$) was measured following the spectrophotometric technique of Clayton and Byrne (1993) using the m-cresol purple indicator (DOE, 1994). 0.0047 pH units were added to the pH experimental values in order to take into consideration the recommendations by Lee et al. (2000). A system similar to that described by Bellerby et al. (1995) was developed in our lab. The pH_t measurements were carried out using a Hewlett Packard Diode Array spectrophotometer in a 25°C-thermostated 1-cm flow-cell using a Peltier system. A stopped-flow protocol was used to analyse seawater previously thermostated to 25°C for a blank determination at 730, 578 and 434 nm. The flow was restarted, and the indicator injection valve switched on to inject 10 µl dye through a mixing coil (2 m). Three photometric measurements were carried out for each injection in order to remove all dye effect on the seawater pH_t measurement. Repeatedly, seawater measurements of the different Certified Reference Materials (CRM provided by Dr. Dickson, Scripps Institution of Oceanography) samples gave a standard deviation of ± 0.0015 (n = 54).

The total alkalinity of seawater (A_T) was determined by titration with HCl to the carbonic acid end point using two similar potentiometric systems, as described in more detail by Mintrop et al. (2000). In order to yield an ionic strength similar to open ocean seawater, the HCl solution (25 l, 0.25 M) was made from concentrated analytical grade HCl (Merck®, Darmstadt, Germany) in 0.45 M NaCl. The acid was standardised by titrating weighed amounts of Na_2CO_3 dissolved in 0.7 M NaCl solutions. The total alkalinity of seawater was evaluated from the proton balance at the alkalinity equivalence point, $pH_{equiv} = 4.5$, according to the exact definition of total alkalinity (Dickson, 1981). The performance of the titration systems was monitored by titrating different samples of certified reference material (CRM, batch 42) with known inorganic carbon and A_T values. The agreement between our data and CRM values was within ±1.5 µmol kg^{-1}. Total inorganic carbon (C_T) is computed from experimental values of pH_t and total alkalinity, using the carbonic acid dissociation constants of Mehrbach after Dickson and Millero (1987). This set of constants presented the best agreement between $C_T(pH, A_T)$ calculations and certified C_T values for CRM, batch 42, with a C_T residual of ± 3 µmol kg^{-1}, n=54 (Millero, 1995, Lee et al., 1997).

Fugacity of carbon dioxide (fCO_2) in the air and in surface seawater was determined using a flow system similar to the unit designed by Wanninkhof and Thoning (1993) and developed by Frank J. Millero´s group at the University of Miami. The equilibrator used is based on the design by R.F. Weiss and described by Butler et al. (1988). The concentration of CO_2 in the air and in the equilibrated air sample was measured with a differential, non-dispersive, infrared gas analyser supplied by LI-COR (LI-6262 CO_2/H_2O Analyser). The sample was measured wet and the signal corrected for water vapour using the water channel of the LI-COR detector. The instrument was operated in the absolute mode and gathered CO_2 concentrations directly from the instrument. The LI-COR instrument analyses the concentration of CO_2 every six seconds, then averaged these values over a 5-min interval, and recorded them. Atmospheric air was pumped at the bow of the ship and measured every hour. The system was calibrated by measuring two different standard gases with mixing ratios of 348.55 and 520.83 ppm CO_2 in the air. These calibrated standards were provided by the National Oceanographic and Atmospheric Administration and they are traceable to the World Meteorology Organisation scale. Our system has demonstrated a precision of less than 1 µatm and is accurate, relative to standard gases, to 2 µatm. Fugacity of CO_2 in the seawater is calculated from the measured xCO_2 (mol fraction of CO_2 gas corrected to dry air and to the pressure of 1 atm).

Gelbstoff

Gelbstoff water was taken in dark glass bottles which were previously cleaned and washed with HCl acid. The samples were analysed on board within 3 hours of having taken them by spectrofluorometry. The values of gelbstoff or yellow substance were obtained using the methodology described by Determann et al. (1994, 1996). The samples were measured with a spectrofluorometer SHIMADZU RF-1501 at an excitation wavelength of 341 nm and the intensities taken at emission wavelength between 350 and 500 nm. Gelbstoff fluorescence is derived from the emission spectra and obtained in Raman units.

All samples were taken using the procedures established in the WOCE Operations Manual, WHP Office Report WHPO 91-1/WOCE Report No.68/91.

4.3.2 Preliminary Results

The temperature/salinity diagrams made from the CTD casts (Fig. 10) shows at intermediate waters the presence of Antarctic Intermediate Water (AAIW) at around

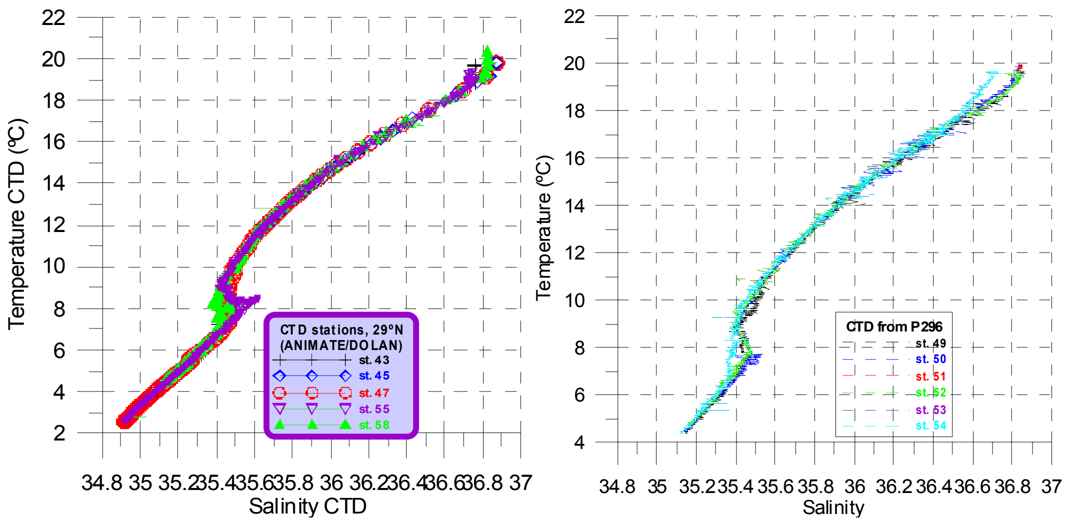

Figure 10: T/S diagrams from CTD stations of POSEIDON cruise 296 along 29°N (left) and between Tenerife and Gran Canaria (right).

1000 m of depth at 29°N, except in station 55, done a few days later and to the east of ESTOC, where the Mediterranean Water (MW) is more explicit. Some stations between Gran Canaria and Tenerife Islands have a presence of MW, showing different mixing states of the AAIW and MW water masses too; stations to the north have more Mediterranean water than those located towards the south of the channel between both islands, obviously more influenced by the AAIW.

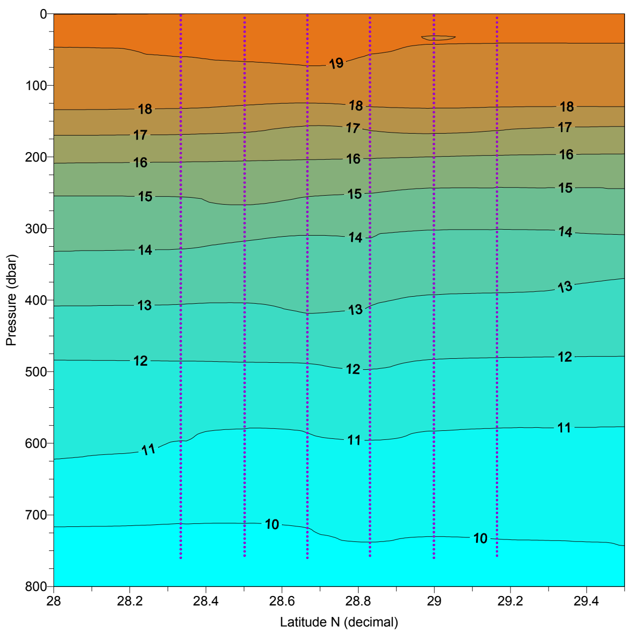

Figure 11: Temperature variation with latitude from the 6 XBT launches (crosses, Fig. 9).

Figure 11 shows the XBT results stating the variation of the temperature with the latitude as going north from Las Palmas harbour towards station ESTOC, corresponding with the last XBT launch to the ESTOC site. This section started in 1995 and it has been continuously sampled since then. Furthermore, it has generated a set of relevant information about the North Atlantic Central Water (NACW) variability, and its formation process in the most southern area where the process takes place.

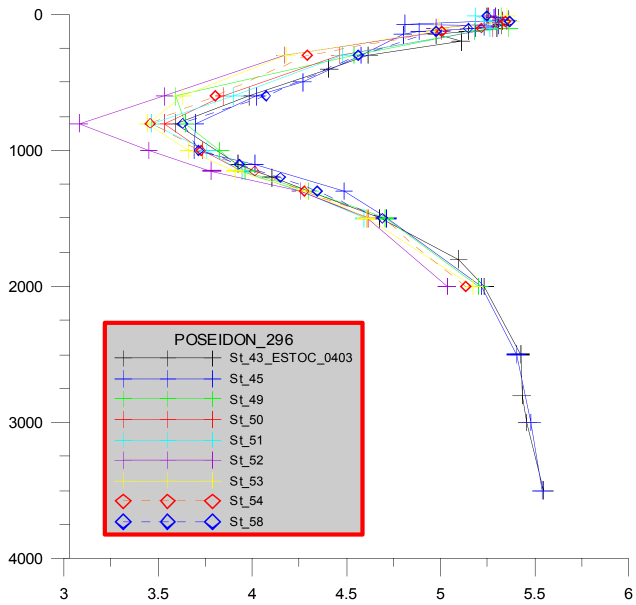

Figure 12: Evolution of the oxygen values from surface to the depth sampled in the stations sampled during R/V POSEIDON cruise 296.

Oxygen shows as a general trend in this area of the subtropical North Atlantic a minimum at around 800 m for all the sampled stations, having the lowest values at the station located southern most. The minimum encountered in the 29°N area is usually located around 800-1000 m with values in the range of 3.6-3.8 ml/l. However, the stations in the channel between Tenerife and Gran Canaria have a tendency towards lower values and in fact, station #52 shows a minimum of about 3.1 ml/l, which denotes the presence of Antarctic Intermediate Water (Fig. 12).

6. List of Stations

Station - No.	Date 2003	Description	LAT		LONG		WD [m]	Remarks
	04.04.	Beginnung of research work						
41-1		XBT #1	28-20	N	015-20	W		
41-2		XBT #2	28-30	N	015-20	W		
41-3		XBT #3	28-40	N	015-20	W		
41-4		XBT #4	28-50	N	015-20	W		
41-5		XBT #5	29-00	N	015-20	W		
41-6		XBT #6	29-10	N	015-20	W		
42	05.04.	station end	29-10,62	N	015-54,42	W	3628	SBU recovered
43-1	05.04.	CTD/Rosette	29-10,15	N	015-24,83	W	3601	
43-2	05.04.	CTD/Rosette	29-09,67	N	015-25,08	W	3603	
43-3	05.04.	NOAA buoy	29-09,91	N	015-25,08	W	3603	
44-1	06.04.	array released	29-10,18	N	015-25,68	W	3604	remaining-mooring ANIMATE/ESTOC several times released, did´nt rise
44-2		Inductiv modems	29-10,79	N	015-25,61	W	3603	test
44-3		Transducer	29-11,23	N	015-55,09	W	3630	
45	07.04.	CTD/Rosette	29-11,20	N	015-55,53	W	3630	
46	07.04.	array released	29-10,70	N	015-55,20	W	3629	MSD-mooring
47	07.04.	CTD/Rosette	29-11,20	N	015-55,00	W	3630	
48-1	08.04.	Dummy (25 spheres)	29-09,11	N	015-52,88	W	3627	DOLAN deployment
48-2		recovery Dummy	29-11,18	N	015-54,77	W	3629	
48-3		DATA Buoy DOLAN	29-11,33	N	015-54,89	W	3630	
49	09.04.	CTD/Rosette	28-57,04	N	015-35,00	W	3609	
50	09.04.	CTD/Rosette	28-44,05	N	015-40,05	W	3587	
51	09.04.	CTD/Rosette	28-31,91	N	015-50,11	W	3423	
52	10.04.	CTD/Rosette	27-54,97	N	016-18,04	W	2526	
53	10.04.	CTD/Rosette	28-08,00	N	016-08,88	W	2291	
54	10.04.	CTD/Rosette	28-19,98	N	016-00,01	W	2814	
55	11.04.	Hydrophon	29-10,55	N	015-25,53	W	3603	new release test without effect ESTOC don´t rise
56	11.04.	2 sediment traps	29-04,53	N	015-15,02	W	3589	ESTOC (CI 16) deployment
57	12.04.	telemetry ADCP, current meter	29-04,59	N	015-48,62	W	3623	ANMATE (ACI 2) deployment
58	12.04.	CTD/Rosette	29-10,00	N	015-43,94	W	3621	
	13.04.	breakup due to weather	29-07,65	N	015-22,46	W		

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